

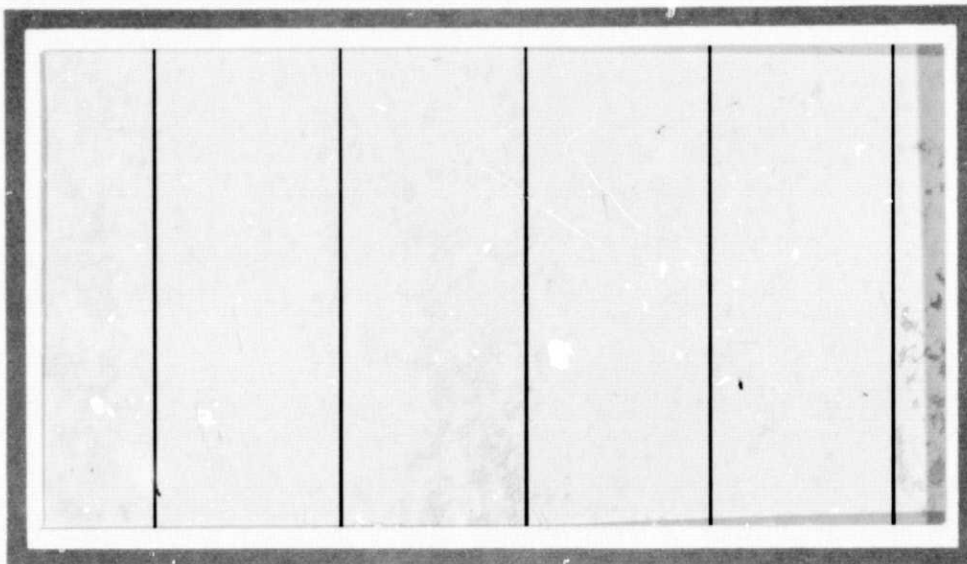
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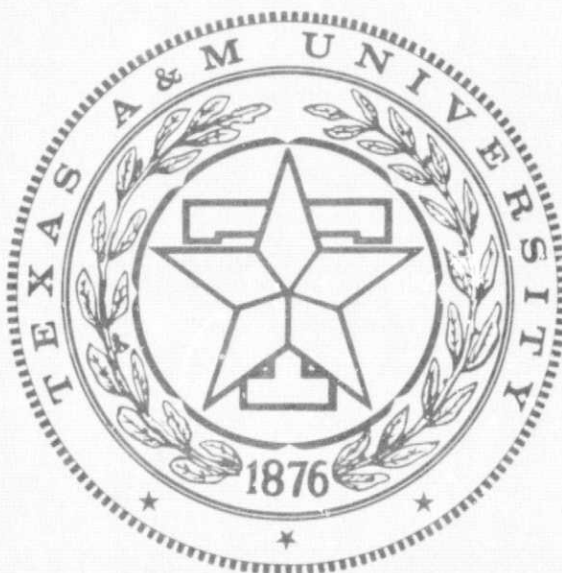
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DEPARTMENT OF MATHEMATICS

TEXAS A&M UNIVERSITY

COLLEGE STATION, TEXAS

FINAL REPORT
IMAGE ANALYSIS LIBRARY
SOFTWARE DEVELOPMENT
Contract NAS-9-14904-3S
February 2, 1976 - May 31, 1977

Prepared For:
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NASA/Johnson Space Center
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INTRODUCTION

The IMAGE ANALYSIS LIBRARY consists of a collection of general purpose mathematical/statistical routines and special purpose data analysis/pattern recognition routines basic to the development of image analysis techniques for support of current and future Earth Resources Programs.

Work performed under this contract was to provide a collection of computer routines and associated documentation which form a part of the IMAGE ANALYSIS LIBRARY.

SOFTWARE DELIVERED

The various routines delivered were grouped into the six Packages named below. Each of the Packages was designed to meet the functional requirements as specified in the IMAGE ANALYSIS LIBRARY outline.

The six Packages, collectively referred to as MATHPAC, are:

- Linear Algebra Package
- Optimization Package
- Statistical Summary Package
- Densities and Distributions Package
- Regression Package
- Statistical Package

A Qualification Test Specification was written and subsequent Acceptance Testing of all MATHPAC routines was successfully completed March 8, 1977. The set of routines, arranged by Package, which were delivered to NASA appear on the following six pages.

LINEAR ALGEBRA PACKAGE

<u>Name</u>	<u>Purpose</u>
MINV DMINV	Computes the inverse of a real, non-singular matrix by Gauss-Jordan elimination with pivoting.
DECOMP	Decomposes a row-permuted real, square matrix into upper triangular and unit-diagonal lower triangular factors
SOLVE	Solves the real system $AX=B$ given vector B, and the factorization of A(DECOMP) and a permutation vector (provided A is non-singular)
IMPRUV	Uses the factorization from DECOMP and the solution from SOLVE to obtain a working precision solution of the above system of equations
MCHSKY	Computes the modified Cholesky factorization of a real, symmetric, positive-definite square matrix; uses this decomposition to compute the inverse of the given matrix
GINV } DOT }	Computes the generalized inverse (pseudo-inverse) of a real matrix
SVD } QRBD } HOUSE } GIVENS }	Computes the singular value decomposition of a real matrix and (optionally) suitably transforms the right hand sides of systems of equations involving the given matrix
SEIGEN	Computes the eigenvalues and eigenvectors of a real, symmetric matrix
EIGEN UNPK BALANC BALBAK HORZ ELMHES ELTRAN	Computes the eigenvalues and (complex) eigenvectors of a given real matrix

OPTIMIZATION PACKAGE

<u>Name</u>	<u>Purpose</u>
DFMCG	Calculates the unconstrained minimum of a function of several variables by the conjugate gradient method
DFMFP	Calculates the unconstrained minimum of a function of several variables using the method of Davidon-Fletcher-Powell
DFMSD	Calculates the unconstrained minimum of a function of several variables using the method of steepest descent
DSRCH	Performs the linear search for the above gradient methods
ZERO	Approximates the real zeros of a function of one variable without the use of derivatives
LOCMIN	Calculates the local minimum of a function of a single variable without the use of derivatives
GLOMIN	Calculates the global minimum of a function of a single variable without the use of derivatives
DNEWT	Approximates the real zeros of a function of one variable (Newton's Method)
LSTSQ	Unconstrained least squares
CLSTSQ LDP NNLS	Solves the least squares problem with linear inequality constraints
QUAD	
LINPRO	
QM431 INITIA NEWBAS SORT PIVOT	Solve complementary problem; called by QUAD & LINPRO

STATISTICAL SUMMARY PACKAGE

<u>Name</u>	<u>Purpose</u>
ABMOM1	Absolute moments
CMONTS	Moments
CVAR	Coefficients of variation
GROP1	Grouping Data
IQRNG	Interpercentile range
MEDIAN	Median
MNDEV	Mean deviation
ORDER	Ordering data
ORDER2	Ordering data (with additional parameters)
ORSEG	Ordering data (with time efficiency)
QUANT	Quantiles
RANGE	Range
SDEV	Standard deviation
CORRE	Computes means, standard deviations, sums of cross-products of deviations, and correlation coefficients
HIST	Histogram
CUMDIS	Empirical cumulative distribution
PLOT3	Plot of single-valued functions

DENSITIES AND DISTRIBUTIONS PACKAGE

<u>Name</u>	<u>Purpose</u>
BETINC	Incomplete Beta distribution
BIN	Binomial distribution
CHI2	Chi Square distribution
DERFF } ERFF }	Error function
FISH	Fisher's distribution
GAMINC	Incomplete Gamma distribution
HYTRIC	Hypergeometric distribution
POIS	Poisson distribution
STUDIS	Student's distribution
FISHIN	Inverse Fisher's distribution
PHINV	Inverse Normal distribution
STUDIN	Inverse Student's distribution
MULNOR	Normal density function - multivariate
CHI } CHIP }	Chi Square random number generator
GAMS	Incomplete Gamma random number generator
GENER } TGEN }	Multivariate random number generator
IBINV	Generate random numbers from a Binomial distribution
KPSNLG } KPSNSM }	Poisson random number generator
ZOR	Random number generator
BIN2	Binomial coefficient
FACTOR	Complete Gamma (Factorial) function
FCTRLG	Log(n!)
ZARF	Complete Gamma function

REGRESSION PACKAGE

<u>Name</u>	<u>Purpose</u>
MULREG	Multiple linear regression
LSQREG	Nonlinear least squares parameter estimation

STATISTICAL TESTS PACKAGE

<u>Name</u>	<u>Purpose</u>
FISHXT	Fisher-exact test
HANS	Hans Riedwyl goodness of fit test
KOLSMR	Kolmogorov-Smirnov goodness of fit test
ANOV1	One way analysis of variance
ANOV2	Two way analysis of variance
GOSSET	Comparisons of means and variances from Normal distributions
SCHEFE	Multiple Range Test
TTEST	T^2 test on means
BEHERN T2DIFF COVARI POOLT2	Multivariate Normal Comparisons of Means

DOCUMENTATION DELIVERED

Documentation was prepared for each of the Packages in accordance with the guidelines specified in the statement of work and agreed upon by the Facilities Configuration Management Office. The following documents were delivered to NASA/JSC on May 15, 1977:

1. FCMO Documentation: Linear Algebra Package
2. FCMO Documentation: Optimization Package
3. FCMO Documentation: Statistical Summary Package
4. FCMO Documentation: Densities and Distributions Package
5. FCMO Documentation: Regression Package
6. FCMO Documentation: Statistical Tests Package

In addition to the NASA-required FCMO documentation, the following documents were prepared and will be delivered to NASA/JSC by June 30, 1977:

1. IMAGE ANALYSIS LIBRARY (MATHPAC): Linear Algebra Package User's Guide
2. IMAGE ANALYSIS LIBRARY (MATHPAC): Optimization Package User's Guide
3. IMAGE ANALYSIS LIBRARY (MATHPAC): Statistical Summary Package User's Guide
4. IMAGE ANALYSIS LIBRARY (MATHPAC): Densities and Distributions Package User's Guide

5. IMAGE ANALYSIS LIBRARY (MATHPAC): Regression Package User's Guide
6. IMAGE ANALYSIS LIBRARY (MATHPAC): Statistical Tests Package User's Guide